Teaching Intelligence

David N. Perkins and Tina A. Grotzer
Harvard University

Efforts to improve human intelligence and thinking have a long history and a lively presence in a number of programs and approaches. Many studies have demonstrated that targeted interventions can teach people to think better within particular subject matters and in some general ways as well, with transfer beyond the kinds of tasks used in instruction and moderate persistence. Effective interventions reorganize learners' thinking with strategies, metacognition, and other means, not just practice-up skills. However, do such improvements genuinely constitute gains in intelligence? They only sometimes and modestly advance intelligence in the sense of IQ, but the authors argue that this essentialist sense of intelligence is flawed. Taking a more eclectic view of intelligence, the interventions reviewed here and others like them teach intelligence because they provide people with the psychological resources to think better across a range of contexts.

Aristotle looked toward a better way of thinking. In his *Analytics* (Ross, 1877/1965), Aristotle introduced the logical form of the syllogism as a guide to reliable inference. Francis Bacon pondered the process of reaching reliable conclusions about the empirical world and foregrounded the importance of seeking disconfirmation. Alfred Binet thought that children could become more able thinkers. Of slower learners, he had this to say: "What they should learn first is not the subjects ordinarily taught, however important they may be; they should be given lessons of will, of attention, of discipline; before exercises in grammar, they need to be exercised in mental orthopedics; in a word they must learn how to learn" (as cited in Gould, 1981, p. 154). The spirit of Aristotle, Bacon, and Binet thrives today in a host of programs and approaches designed to better the thinking of children and adults.

Such efforts are motivated by the widespread recognition that we often do not use our minds as well as it appears we could. Langer (1989) investigated the phenomenon she calls *mindlessness*—the shallow processing of information that allows outrageous anomalies to pass by unnoticed. Dweck and her colleagues (Dweck & Bempechat, 1980; Dweck & Licht, 1980) have demonstrated how tacit beliefs in the limitations of one's intelligence become self-fulfilling prophecy. Several investigators have provided evidence of the shallow, one-sided reasoning people use in everyday issues, sometimes with demonstrations that people can easily do better if prompted (e.g., Baron, Granato, Spranca, & Teubal, 1993; Kuhn, 1991; Means & Voss, 1996; Perkins, 1985; Perkins, Farady, & Bushey, 1991). Stanovich (1994) referred to a persistent syndrome of *dysrationalia:* "The key diagnostic criterion for dysrationalia is a level of rationality, as demonstrated in thinking and behavior, that is significantly below the level of the individual's intellectual capacity" (p. 11). Perkins (1995) summed up the situation with four characteristic default tendencies: Although generally functional, thinking too often tends to be hasty (impulsive, insufficient investment in deep processing and examining alternatives), narrow (failure to challenge assumptions, examine other points of view), fuzzy (careless, imprecise, full of conflations), and sprawling (general disorganization, failure to advance or conclude). The four defaults can be attributed to the pattern-driven character of cognition as well as ego defense and other mechanisms.

Perhaps education can help. General education has a considerable impact on IQ (e.g., Brody, 1992). Interventions that are focused on thinking might help people think better in various ways and even raise their IQ. But can better thinking be taught, and do any gains amount to becoming genuinely more intelligent?

The idea that people can learn to think substantially better in a general long-lasting way is controversial, reflecting a vigorous debate about the nature of intelligence. Today, diverse theories of intelligence vie for recognition, including classic g theory (e.g., Jensen, 1980), neural module views (e.g., M. Anderson, 1992), Sternberg's (1985) triarchic theory of intelligence, Gardner's (1983) theory of multiple intelligences, and many more. To organize the diversity, Perkins (1995) identified three broad styles in theorizing about intelligence and thinking: neural, experiential, and reflective. Of course, theorists

David N. Perkins and Tina A. Grotzer, Graduate School of Education, Harvard University.

Much of the thinking behind this article was supported by grants from the John D. and Catherine T. MacArthur Foundation and the Spencer Foundation, for which we are grateful. Of course, the views expressed are ours and do not necessarily reflect those of the foundations. We appreciate the counsel of Jonathan Baron, John Bruer, and Howard Gardner on the first draft of this article.

Correspondence concerning this article should be addressed to David N. Perkins, Graduate School of Education, Harvard University, Longfellow Hall 315, Cambridge, MA 02138. Electronic mail may be sent via Internet to david_perkins@pz.harvard.edu or to tina_g@pz.harvard.edu.

Vol. 52, No. 10, 1125–1133

in the same style often disagree vehemently about the particulars even as they share the broad commitments of the style, and some theorists adopt a position that combines two or even all three of these styles.

Neural intelligence refers to the contribution of biological variations in neural efficiency (global or sometimes modular) to intelligent behavior and includes the belief of some investigators that g has a basis in neural efficiency (e.g., M. Anderson, 1992; Herrnstein & Murray, 1994; Jensen, 1980). It should be noted that advocates of this position are not generally neuroscientists, and the evidence implicating specific neural mechanisms is quite indirect (Brody, 1992; Ceci, 1990). Experiential intelligence refers to the contribution of knowledge and experience to intelligent behavior, acknowledging the role of crystallized intelligence (Cattell, 1963) and knowledge and cognitive skills that are highly tuned to particular fields and endeavors (e.g., Bereiter & Scardamalia, 1993; Ceci, 1990; Ericsson & Smith, 1991). Finally, reflective intelligence refers to the contribution of knowledge about thinking and reflective self-guidance to intelligent behavior (e.g. Baron, 1985; Baron & Sternberg, 1986; Nickerson, 1989; Nickerson, Perkins, & Smith, 1985; Perkins, 1995; Sternberg, 1985). Most instructional efforts to enhance intelligence focus on reflective intelligence.

Against this backdrop, one challenge to the idea of teaching intelligence comes from the experiential camp, where researchers have often argued that cognitive skills are inherently context bound (cf. Ceci, 1990; Detterman, 1992; Lave, 1988). But the larger challenge comes from the neural camp and from others who focus on IQ as the index of success. Jensen (1983, 1989), Herrnstein and Murray (1994), and Brody (1992; not a neural advocate) assessed interventions designed to enhance cognitive functioning through their impact on IQ. After reviewing a number of cases, they concluded that interventions usually have an impact magnitude of half a standard deviation or less, tend to enhance testmanship more than general cognitive efficacy, and yield effects that dwindle and vanish within a few years (see Campbell & Ramey, 1994, for a rare and partial exception).

With the skeptics acknowledged, it becomes important to look at the empirical picture. What have programs achieved that were designed to enhance people's thinking? In appraising their accomplishments, it is useful to bear in mind three important dimensions of success that are highlighted by the skeptics: the magnitude, generality, and persistence of impact on thinking.

Some Positive Findings

An increasing number of studies provide evidence that targeted attempts to teach people to think better can be worthwhile. We review a small sample here; this sample was chosen to provide a sense of the diversity of approaches, populations, and methods but necessarily leaves out many important and informative works.

Thinking in General: Project Intelligence

Project Intelligence, also known as Odyssey, a course that can easily fill a year or more, seeks to teach both the strategies and spirit of good thinking in reasoning, problem solving, decision making, inventive thinking, and other areas. Six instructional units designed for seventh graders introduce and elaborate strategies and provide abundant practice.

A formal evaluation with students in 24 classes from families of low socioeconomic status (SES) and parental education in a matched sample design showed promising results (Herrnstein, Nickerson, Sanchez, & Swets, 1986). Intervention students made higher performance gains than controls in general aptitude (effect sizes of $d = .43$, $p < .001$, on the Otis–Lennon School Ability Test [Otis & Lennon, 1977]; $d = .11$, $p < .02$, on the Cattell Culture Fair Test [Catell & Cattell, 1961]; and $d = .35$, $p < .001$, on the Test of General Abilities [Manuel, 1962]). They also showed greater gains on tests of the targeted abilities (i.e., problem solving [$d = .46$], decision making [$d = .77$], reasoning [$d = .64$], language [$d = .62$], and inventive thinking [$d = .50$], with each being significant at $p < .001$). Intervention students outperformed controls on an open-ended design problem ($d = .70$, $p < .001$) and on an everyday reasoning task ($d = .50$, $p < .01$) that assessed students' ability to transfer what they had learned to new contexts. Although the persistence of effects was not tested, these positive results suggest that the intervention enhanced the magnitude and reach of students' intelligent behavior at least in the short term.

Thinking in General: The Philosophy for Children Program (PFC)

This well-known program by philosopher Matthew Lipman directly involves students in metacognition (Lipman, 1976; Lipman, Sharp, & Oscanyan, 1980). Versions for different levels, from kindergarten to high school, use Socratic discussion to help students consider such ideas as the process of inquiry, inductive reasoning, and the nature of explanation through stories that are focused on everyday events.

The Educational Testing Service conducted extensive evaluations of the PFC Program, which demonstrated positive effects of the weekly 2.25-hour intervention. For instance, in a study of 400 fifth to eighth graders, PFC students showed significant gains ($p < .0001$) in mathematics performance (increase in score of 6.11 points) when compared with controls (up 4.50 points) and in reading performance (up 8.33 points) when compared with controls (up 5.00 points) on the standard scores of the Metropolitan Achievement Tests (Psychological Corporation, 1978). Although differences in reasoning are reported, such as drawing inferences, ideational fluency, and curiosity (significant at $p < .05$, or less), effect sizes are not provided, so it is difficult to assess the magnitude of change (see Lipman et al., 1980). Later studies reported transfer of learning (e.g., Iorio, Weinstein, & Mar-

tin, 1984; Shipman, 1983). An earlier study by Lipman and Bierman (as cited in Lipman et al., 1980) found significant, persistent gains in reading 2.5 years later ($p < .01$).

Thinking in Mathematics: Schoenfeld's Heuristic Instruction

Schoenfeld (1982; Schoenfeld & Herrmann, 1982) taught college students heuristics for mathematical problem solving along with a managerial, self-monitoring process that, he argued, students needed to organize their patterns of problem solving and use heuristics well.

Schoenfeld (1982) compared the pre- and posttest performance of the 11 course participants with 8 control students in a similar class by having them write down the approaches that they tried for solving problems and reasons why they tried them. Intervention students solved significantly more posttest problems (2.64 of 5.00) than controls (0.38). They gained 48 points, whereas controls lost 2 points on a transfer test of recognizing related problems. Intervention students made greater gains in generating plausible approaches to problems (51.4 on a 0–100-point scale) than controls (10.0) and reported greater gains in systematicity and thoughtfulness, such as knowing how to start (44) when compared with controls (no change). *P* values were not reported. Schoenfeld and Herrmann (1982) found that intervention students sorted transfer problems on the posttest in ways that more closely correlated (.72) with how experts sorted problems than on the pretest (.54). This gain was significantly higher ($p < .01$) than that of controls (pretest =.55, posttest = .42). Schoenfeld (1982) reported parallel results on a larger, previous study with no control group in justifying the small *n*. Although no information exists on the persistence of the effects, their magnitude and generality demonstrate the enhanceability of intelligent behavior.

Thinking in Science: Cognitive Acceleration Through Science Education (CASE) Program

In the CASE Program, Adey and Shayer (1993) taught lessons on patterns of thinking in science (such as the isolation and control of variables) while attending to metacognition and transfer of knowledge and strategies. They introduced cognitive dissonance around particular puzzles so students would examine assumptions and rethink prior conceptions.

A formal evaluation of 194 participants (11- to 12-year-olds) in a two-year intervention and 230 control students was conducted. Although few significant results existed at the end of the intervention, measurements a year later showed significant improvements for 12-year-old boys ($d = .72$, $p < .05$) and 11-year-old girls ($d = .60$, $p < .025$) from the CASE group on school science achievement tests. Two years later, differences existed (significant at $p < .05$, or less) for 12-year-old boys and 11-year-old girls in science ($d = .96$ and $d = .67$, respectively), math ($d = .50$ and $d = .72$, respectively), and English ($d = .32$ and $d = .69$, respectively) between CASE students and controls on the General Certificate of Secondary Education Exam (GCSE). (The GCSE is an examination taken in England and Wales and is explained in Adey & Shayer, 1994, p. 92.) Significant effects were also found for 12-year-old-girls in English ($d = .44$). The persistence and increased magnitude of effects from the initial posttesting to two years later as well as the transfer to other subject matters suggest that the strategies taught helped students become more intelligent learners.

Coping Thoughtfully With School: Practical Intelligence for Schools (PIFS)

The PIFS program was built around the notion of practical intelligence—that particular settings call for somewhat situated coping strategies (Sternberg & Wagner, 1986). PIFS attempts to build students' understanding and coping around five themes: knowing the point of the topic, technique, and assignment; knowing one's strengths and weaknesses; knowing the demands of different subjects and assignments; knowing steps and strategies; and reflection in assessing and revising (Williams et al., 1996).

Evaluations showed that the experimental group (E) of PIFS students gained more than the non-PIFS control group (C). For instance, in an evaluation including 260 fifth and sixth graders, PIFS students did better on measurements of practical (five-point scale) and academic abilities (three-point scale) in writing: practical abilities, E = 2.70, C = 2.53, $F(1, 259) = 4.22$; and academic abilities, E = 2.37, C = 2.09, $F(1, 259) = 5.71$. They also did better on practical abilities in reading, E = 3.00, C = 2.60, $F(1, 259) = 15.53$; homework, E = 2.94, C = 2.44, $F(1, 258) = 24.10$; and test taking, E = 2.85, C = 2.33, $F(1, 242) = 23.49$, all significant at $p < .05$, or less except as otherwise noted. PIFS students were rated more apt to display active-learning skills and behaviors (Chen, 1993). Although the persistence of effects is not yet known, the transfer of PIFS learning to school tasks and subject matters as well as the magnitude of effects suggest that the PIFS intervention helped students behave more intelligently.

These studies sampled the positive outcomes that have been found in teaching intelligent behavior. Other researchers have also reported positive outcomes (see, e.g., Edwards & Baldauf, 1983; Palincsar & Brown, 1984; and such books as Jones & Idol, 1990; Nickerson, Perkins, & Smith, 1985; Segal, Chipman, & Glaser, 1985; Whimbey, 1975, for program reviews).

Of course, not all efforts have been successful. For instance, the Productive Thinking Program, a self-instructional program of 15 lessons designed to teach inventive thinking to fifth and sixth graders through a series of mysteries, was one of the earliest programs in this conceptual area (Covington, Crutchfield, Davies, & Ol-

ton, 1974). The Productive Thinking Program met with mixed results (Mansfield, Busse, & Krepelka, 1978). Students improved on problems that closely paralleled those in the program but without transfer to other kinds of problems (Moreno & Hogan, 1976). This might have been due to the short length of the program and perhaps to the lack of generality of the problems and approach (Nickerson et al., 1985).

For another mixed picture, the Instrumental Enrichment Program may serve some populations better than others. Originally developed for low-functioning learners, Instrumental Enrichment has a mediator scaffold the learner's problem solving on over 400 abstract "context-free" problems over a two-year period (Feuerstein, Rand, Hoffman, & Miller, 1980). Low-functioning, low-SES 12–15-year-olds improved on tests of interpersonal conduct, self-sufficiency, and adaptation to work demands as well as on an Army intelligence test two years later (Feuerstein et al., 1981; Rand, Tannenbaum, & Feuerstein, 1979). However, in an extensive study in a regular school setting, ordinary learners did not show improvements in academic performance (Blagg, 1991). This might have been due to an Aptitude × Treatment interaction (Cronbach & Snow, 1977). The abstract nature of the tasks and the focus on developing underlying mental operations might speak to the deficiencies of the low-functioning learners but not to the needs of ordinary students. Other work in the broad spirit of a Treatment × Aptitude interaction suggests that aligning instruction with students' intellectual strengths and weaknesses can have a considerable impact on learning (Sternberg, Ferrari, Clinkenbeard, & Grigorenko, 1996).

Studies such as these can help to fill out the picture of what elements are important in instruction that teaches for intelligence. Clearly, attention to transfer, program length, and suitable population are just some of the elements that determine a program's success or failure.

The Reorganizational Character of Teaching Intelligence

With such examples as those given above, what generalizations about method seem warranted? Perhaps the most salient feature is the reorganizational character of teaching thinking. Successful programs invariably seek to reorganize thinking, not just to exercise it up. They teach strategies, concepts, attention to one's thinking, caution about traps of thinking, and the like.

Specific evidence speaks to the importance of a reorganizational approach. Schoenfeld (1979) and A. L. Brown and Palincsar (1989) reported studies contrasting the learning of cognitive strategies under what might be called tacit-strategy and explicit-strategy conditions. Learners in both groups participated in demonstrations that were based on the strategies. The strategies were made explicit and focal in the explicit-strategies group but not in the tacit-strategies group. Both groups did practice activities. The tacit-strategies condition had minimal impact, whereas the explicit-strategies condition considerable impact.

If reorganization is central, what is it that needs to be reorganized? A range of research points to five categories of cognitive reorganization (CORE categories): strategies, metacognition, dispositions, distributed intelligence, and transfer. We comment on each briefly.

Strategies

Most interventions designed to improve thinking teach strategies. These range from problem solving, decision making, mnemonic, and other general-purpose strategies to strategies more focused on the needs of particular domains, such as mathematical problem solving or computer programming. Strategies reorganize thinking by providing patterns to follow that work against the defaults mentioned earlier (hasty, narrow, fuzzy, and sprawling) and prescribe effective heuristics for the kinds of thinking in question, for instance, mathematical induction for mathematical problem solving.

Metacognition

The term *metacognition* has a range of usage in psychology. As used here, it refers to monitoring and management of one's thinking, including making plans before a thinking episode, regulating during the episode, and reflecting back afterwards to revise and plan future practices (e.g., Scardamalia & Bereiter, 1985; Sternberg, 1985; Whimbey & Lochhead, 1982). Metacognition reorganizes thinking by providing on-line monitoring and redirection.

Dispositions

Whereas thinking abilities are focused on what a thinker is able to do, thinking dispositions focus on what a thinker is inclined to do (e.g., Baron, 1985; Ennis, 1986; Perkins, Jay, & Tishman, 1993). Without appropriate dispositions, thinking abilities can lie fallow. Dispositions emanate in part from underlying beliefs, for instance, beliefs in the importance or unimportance of effort in learning and problem solving (Dweck & Bempechat, 1980; Dweck & Licht, 1980). Dispositions also reflect what Dewey (1933) called "habits of thought" (p. 35). Perkins et al. (1993) argued that thinking dispositions consist of both sensitivity and inclination: Thinking dispositions reorganize thinking through the sensitivity to detect occasions that call for a particular pattern of thinking and the inclination to follow through.

Distributed Cognition

Traditionally, intelligence is viewed as a quality of mind and brain, but intelligent functioning also depends on physical, social, and symbolic support systems (Salomon, 1993). Physical support systems, from paper and pencil to the computer program Mathematica (Wolfram, 1988), provide short-term memory and computational aids. Social support systems such as team thinking, the use of experts, and teleconferencing allow the pooling of expertise and collaborative brainstorming. Symbolic resources

for thinking include the everyday language of thinking—terms such as hypothesis, option, and evidence, which carry structures and standards that guide thinking (e.g., Olson & Astington, 1993; Tishman & Perkins, 1997)—as well as more specialized concepts and symbol systems. Some approaches to the teaching of thinking make extensive use of graphic organizers—diagrammatic ways of representing evidential and other relationships that provide both physical and symbolic support (McTighe & Lyman, 1988). Attention to distributed intelligence reorganizes thinking by guiding learners in the use of physical, social, and symbolic supports.

Transfer

Transfer of learning is a critical issue in teaching intelligence. Considerable research shows that transfer is hard to come by, particularly far transfer (e.g., Detterman & Sternberg, 1992; Salomon & Perkins, 1989; Thorndike, 1923). Some advocates of the contemporary view called *situated learning* argue that learning is inherently highly contextual and the prospects of generally applicable learning low (J. S. Brown, Collins, & Duguid, 1989; Lave, 1988; but see J. R. Anderson, Reder, & Simon, 1996, for a critique of the situated view). However, Salomon and Perkins (1989) among others argued that transfer can be, and has been, attained when the conditions of learning foster reflective abstraction, thorough practice on deliberately diverse cases, or both, which are conditions that are not usually met. All the programs reviewed above showed some degree of transfer. Transfer reorganizes thinking by broadening the application of acquired concepts and behaviors.

The CORE categories contribute to an appraisal of teaching intelligence in three ways. First, they describe what successful interventions do. Second, the CORE categories have normative force. They constitute theory-based guidelines for effective instructional design. This does not mean that an effective program has to thoroughly address all five to have impact, because spillovers from one to another are natural. However, when a program does not attend explicitly to a category, the program may benefit from supplementation in that area. Third, the CORE categories underscore the complexity of teaching thinking. Whereas many approaches to teaching thinking seem rather simplistic, decision making, problem solving, understanding and other areas of thinking are multifaceted domains, as general practices and even more so within particular contexts. Perkins (1995) described them as "realms" (p. 249) of knowledge, areas of generalized expertise that require extended thoughtful learning.

Teaching Cognitive Reorganization Through the Disciplines

The programs discussed so far by and large have a top-down character: Thinking is the subject to be taught. Another pedagogical tradition in this area is more bottom-up: The teaching of thinking occurs not only within the subject matters but also capitalizes on the thinking demands as they arise from the context. Although the strategies and concepts introduced often have a somewhat generic transferable character (Bereiter & Scardamalia, 1993; Bruer, 1993; Clement, 1991), their contextualization encourages more situated and expert thinking. This approach is also often called *infusion* (e.g., Swartz & Perkins, 1989). Several published approaches provide teachers with general infusion guidelines (e.g., Perkins, Goodrich, Tishman, & Mirman-Owen, 1994; Swartz & Parks, 1994; Tishman, Perkins, & Jay, 1995).

One problem in appraising the impact of infusion from the standpoint of teaching intelligence is that the formal studies tend to focus on gains in the understanding of disciplinary content, with less attention to general impact on thinking within or across disciplines. However, the existing research is promising. For example, the ThinkerTools Inquiry Project is a middle school science program about Newtonian dynamics in which the class becomes a research community and students propose and test out competing theories with the aid of computer models. They compare findings and discuss which models and theories offer the most powerful explanations. It has had a sizable impact not only on students' learning of physics principles but also of inquiry in general (White & Frederiksen, 1995; Horwitz & White, 1986). Research on a strategic reading program called Reciprocal Teaching (Palincsar & Brown, 1984) offers a second example. Students and teachers take turns guiding the group. Students learn to process information differently and to routinely use strategies such as questioning, clarifying, summarizing, and predicting to help comprehend text. Results show that students not only improve their reading scores but their comprehension on other classroom tasks as well (Palincsar, Ransom, & Derber, 1988).

With this encouragement, we turn to examining how infusion can create a learning environment that fosters general cognitive reorganization. Here is a characteristic example drawn from a fifth- and sixth-grade class in the Boston area. Students learning about the Civil War recognized an opportunity to consider a key question from two differing points of view: "Should the South be allowed to secede?" So the teacher divided the class to represent North and South, and students conducted research in groups to prepare for a debate (socially distributed cognition). The students first prepared evidence on their side of the case only, failing to take into account the other side's case. During the first part of the debate, each side argued their own case but found themselves unprepared to rebut the other's case. A reflective discussion guided by the teacher made it plain that the students had failed to consider and anticipate each other's concerns (metacognition).

The teacher took the opportunity to teach some good steps for evaluating differing points of view (strategies). Students then conducted further research considering the arguments in a more evenhanded manner. Soon they had

amassed so much information that it was hard to keep track of it. The teacher encouraged the use of chart paper to map out possible arguments and responses (physically distributed cognition). In the next round of debate, by anticipating each other's cases, the students pushed each other's thinking further and engaged in deeper, more interesting conversation (dispositions). They remarked that although they originally researched the other side of the case to construct a better argument, it also led them to understand what needs their opponents were trying to meet (metacognition). Finally, the teacher guided students through a discussion of other occasions in which attending to both sides of the case could be helpful (transfer).

As this example shows, infusion provides an occasion for cognitive reorganization, in part because it invites dissonance and mediation. These are key mechanisms for initiating conceptual reorganization. The literature on conceptual reorganization (e.g., Posner, Strike, Hewson, & Gertzog, 1982/1992; Strike & Posner, 1985) suggests that reorganization is most likely when learners become aware of the strengths and problems of their current beliefs, understandings, and thinking patterns, (e.g., Clement, 1982; diSessa, 1983; Driver, Guesne, & Tiberghien, 1985; Osborne & Freyberg, 1985). Encountering evidence that a default thinking pattern is problematic can introduce dissonance about the pattern in the learner's mind. At this point of dissonance, learners are ready to accommodate discrepant information by reorganizing their thinking (Berlyne, 1965; Kuhn, 1972). Learners also must understand any replacement pattern well enough to see it as potentially more powerful than the pattern it replaces. Mediation can play a key role here (Feuerstein & Rand, 1974; Vygotsky, 1978). Learners benefit from models, experiences, and guidance in a social context to grow within their zone of present potential. The teacher in the example presented a heuristic for exploring other points of view—helping learners reorganize their thinking around a more powerful pattern.

Although infusion is a promising approach, this is not to imply that it is decidedly better than a stand-alone program. As to an empirically based preference, we know of no data directly comparing the two approaches. Indeed, direct comparisons of programs designed to teach intelligence are difficult. Whether stand-alone or infusion, programs typically have somewhat different objectives and target populations. However, experience tells us that stand-alone and infusion programs have their characteristic weak spots. Stand-alone programs can easily neglect transfer of learning to subject-matter contexts. They also require making space in already crowded school schedules, something many administrators are loathe to do. Infusion programs face different risks. The infusion component can get lost in the focus on subject matter, either left out for the sake of coverage or never made explicit enough to benefit students. Issues such as these have led some researchers to argue that the best approach is to use both when possible (Ennis, 1989; Swartz & Perkins, 1989).

Is Taught Intelligence Real Intelligence?

The evidence says that instructional interventions can help people to handle important kinds of thinking better through cognitive reorganization. Recalling the three dimensions of effectiveness identified earlier, magnitude of effect varies considerably, commonly reaching half a standard deviation and sometimes approaching a standard deviation. Regarding generality, there are several instances of significant transfer across disciplinary boundaries. Appraising persistence calls for longitudinal studies, and, not surprisingly, the information here is more sparse. It appears that enhancements of thinking can last for months or years. However, there is no evidence that they are permanent in the absence of refresher interventions.

Instruction can help people to think better, but have they thereby become more intelligent? Champions of the neural view of intelligence identified earlier would say no (Herrnstein & Murray, 1994; Jensen, 1983, 1989). They might admit that people can learn to think better in some ways, but such effects would not have the broad generality or the persistence of IQ. This pattern of argument reflects what might be called an essentialist position on the nature of intelligence: IQ is an index of general neurological efficiency more than anything else and the essence of intelligence. To appraise the merits of the essentialist position, let us consider two questions: How good of an essentialist view does *g* theory provide? And how appropriate is an essentialist view of intelligence?

As to the first question, *g* theory offers a less than ideal essence in several ways (Brody, 1992; Ceci, 1990). It is an old argument that the existence of a *g* factor need not imply a single mechanism or psychological resource (Thomson, 1916). The evidence linking *g* to basic cognitive operations that supposedly reflect neural efficiency is equivocal, with low to moderate correlations and many alternative interpretations. The correlations that lead to the *g* factor are much weaker in the upper range of IQs, suggesting that *g* may not have the uniform meaning across the IQ range usually ascribed to it (Detterman & Daniel, 1989). IQ generally accounts for only a quarter or less of the variance in school and work performance measures, not a high score for an essence. Arguments that are based on heritability certainly suggest a biological basis for part of IQ, accounting for 50% or 60% of the variance, but the rest of the variance remains, and, also, how much variance heredity explains is not an absolute but depends on opportunities to learn in the culture (Herrnstein & Murray, 1994; Scarr, 1989). Without a clear story about what *g* really represents, it is just a number for a trend. Essentialism is a risky position when one does not know what the essence is.

As to the second question—how appropriate is an essentialist view?—an analogy offers a cautionary note. Suppose an elaborate factor analysis of basketball play-

ers' performance discloses one overarching common factor that accounts for the larger part of the variance. It turns out to be height—"HiQ" so to speak. Players with a greater HiQ tend to play better. A person of essentialist leanings might conclude that basketball ability is most fundamentally a matter of HiQ, with some other peripheral considerations acknowledged. But a more eclectic view could be adopted. Basketball playing is a complex function calling for all sorts of human resources. To map the three categories introduced earlier onto basketball, good basketball ability involves initial endowment (height and like factors), the legacy of experience (fine-honed motor skills, rapid recognition of hazards and opportunities, etc.), and reflective resources (strategic planning, reflective practice, deliberately pumping up one's energy and attitude, etc.). Whereas some attributes might be more influential than others, any major contributing resource would count as part of the ability.

In summary, an essentialist view of intelligence as IQ seems unwarranted: It is inherently flawed and only part of the story behind intelligent behavior in the real world. It appears at least as reasonable to assert an eclectic view of intelligence as involving neural efficiencies of some sort, the legacy of experience in a domain, and informed reflective management of one's thinking. Gauged by an eclectic view of intelligence, intelligence can be taught to at least a limited extent, with more research required to determine how far it is possible to go. Instruction can help people to enhance reflective intelligence with significant generality and persistence. The key to effective interventions appears to be cognitive reorganization that is attentive to such matters as thinking strategies, metacognition, dispositions, distributed cognition, and transfer.

REFERENCES

Adey, P., & Shayer, M. (1993). An exploration of long-term far-transfer effects following an extended intervention program in the high school science curriculum. *Cognition and Instruction, 11*(1), 1–29.

Adey, P., & Shayer, M. (1994). *Really raising standards: Cognitive intervention and academic achievement.* London: Routledge.

Anderson, M. (1992). *Intelligence and development: A cognitive theory.* Cambridge, MA: Blackwell.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25*(4), 5–11.

Baron, J. (1985). *Rationality and intelligence.* New York: Cambridge University Press.

Baron, J., Granato, L., Spranca, M., & Teubal, E. (1993). Decision-making biases in children and early adolescents: Exploratory studies. *Merrill-Palmer Quarterly, 39,* 22–46.

Baron, J. B., & Sternberg, R. S. (Eds.). (1986). *Teaching thinking skills: Theory and practice.* New York: Freeman.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise.* Chicago: Open Court.

Berlyne, D. E. (1965). Curiosity and education. In J. D. Krumboltz (Ed.), *Learning and the educational process* (pp. 67–89). Chicago: Rand McNally.

Blagg, N. (1991). *Can we teach intelligence?* London: Erlbaum.

Brody, N. (1992). *Intelligence.* New York: Academic Press.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393–451). Hillsdale, NJ: Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Bruer, J. T. (1993). *Schools for thought: A science of learning in the classroom.* Cambridge, MA: MIT Press.

Campbell, F. A., & Ramey, C. T. (1994). Effects of early intervention on intellectual and academic achievement: A follow-up study of children from low-income families. *Child Development, 65,* 684–698.

Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology, 54,* 1–22.

Cattell, R. B., & Cattell, A. K. S. (1961). *Culture Fair Intelligence Test* (Scale 2, Forms A & B). San Antonio, TX: Guidance Testing Associates.

Ceci, S. J. (1990). *On intelligence . . . more or less: A bio-ecological treatise on intellectual development.* Englewood Cliffs, NJ: Prentice Hall.

Chen, J. Q. (1993). [PIFS study: Harvard/Yale combined data analysis for fifth and sixth grades]. Unpublished data analysis.

Clement, J. (1982). Student preconceptions of introductory mechanics. *American Journal of Physics, 50,* 66–71.

Clement, J. (1991). Nonformal reasoning in experts and in science students: The use of analogies, extreme case and physical intuition. In J. Voss, D. N. Perkins, & J. Segal (Eds.), *Informal reasoning and education* (pp. 345–362). Hillsdale, NJ: Erlbaum.

Covington, M. V., Crutchfield, R. S., Davies, L., & Olton, R. S. (1974). *The productive thinking program: A course in learning to think.* Columbus, OH: Charles E. Merrill.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and instructional methods: A handbook for research on interactions.* New York: Irvington Publishers.

Detterman, D. K. (1992). The case for the prosecution: Transfer as an epiphenomenon. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial* (pp. 1–24). Norwood, NJ: Ablex.

Detterman, D. K., & Daniel, M. H. (1989). Correlations of mental tests with each other and with cognitive variables are highest for low IQ groups. *Intelligence, 13,* 349–360.

Detterman, D., & Sternberg, R. J. (Eds.). (1992). *Transfer on trial.* Norwood, NJ: Ablex.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the education process.* New York: Heath.

diSessa, A. (1983). Phenomenology and the evolution of intuition. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (pp. 267–298). Hillsdale, NJ: Erlbaum.

Driver, R., Guesne, E., & Tiberghien, A. (Eds.). (1985). *Children's ideas in science.* Philadelphia: Open University Press.

Dweck, C. S., & Bempechat, J. (1980). Children's theories of intelligence: Consequences for learning. In S. G. Paris, G. M. Olson, & H. W. Stevenson (Eds.), *Learning and motivation in the classroom* (pp. 239–256). Hillsdale, NJ: Erlbaum.

Dweck, C. S., & Licht, B. G. (1980). Learned helplessness and intellectual achievement. In J. Garbar & M. Seligman (Eds.), *Human helplessness* (pp. 197–222).. New York: Academic Press.

Edwards, J., & Baldauf, R. B. (1983). Teaching thinking in secondary science. In W. Maxwell (Ed.), *Thinking: The expanding frontier* (pp. 9–26). Philadelphia: The Franklin Institute Press.

Ennis, R. H. (1986). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9–26). New York: Freeman.

Ennis, R. H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher, 18*(3), 4–10.

Ericsson, K. A., & Smith, J. (Eds.). (1991). *Toward a general theory of expertise: Prospects and limits.* Cambridge, MA: Cambridge University Press.

Feuerstein, R., Miller, R., Hoffman, M. B., Rand, Y., Mintzker, Y., & Jensen, M. R. (1981). Cognitive modifiability in adolescence: Cognitive structure and the effects of intervention. *The Journal of Special Education, 15,* 269–286.

Feuerstein, R., & Rand, Y. (1974). Mediated learning experiences: An

outline of the proximal etiology for differential development of cognitive functions. *International Understanding, 9/10,* 7–37.

Feuerstein, R., Rand, Y., Hoffman, M. B., & Miller, R. (1980). *Instrumental enrichment.* Baltimore: University Park Press.

Gardner, H. (1983). *Frames of mind.* New York: Basic Books.

Gould, S. J. (1981). *The mismeasure of man.* New York: Norton.

Herrnstein, R. J., & Murray, C. (1994). *The bell curve: Intelligence and class structure in American life.* New York: Free Press.

Herrnstein, R. J., Nickerson, R. S., Sanchez, M., & Swets, J. A. (1986). Teaching thinking skills. *American Psychologist, 41,* 1279–1289.

Horwitz, P., & White, B. (1986). *ThinkerTools annual progress report.* Cambridge, MA: Bolt Beranek & Newman.

Iorio, J., Weinstein, M. L., & Martin, J. F. (1984). A review of District 24's Philosophy for Children Program. *Thinking: The Journal of Philosophy for Children, 5*(2), 28–35.

Jensen, A. R. (1980). *Bias in mental testing.* New York: Free Press.

Jensen, A. R. (1983). The nonmanipulable and effectively manipulable variables of education. *Education and Society, 1*(1), 51–62.

Jensen, A. R. (1989). Review: Raising IQ without increasing g? A review of the Milwaukee Project: Preventing Mental Retardation in Children at Risk. *Developmental Review, 9,* 234–258.

Jones, B. F., & Idol, L. (Eds.). (1990). *Dimensions of thinking and cognitive instruction.* Hillsdale, NJ: Erlbaum.

Kuhn, D. (1972). Mechanisms of change in the development of cognitive structure. *Child Development, 43,* 833–844.

Kuhn, D. (1991). *The skills of argument.* New York: Cambridge University Press.

Langer, E. J. (1989). *Mindfulness.* Menlo Park, CA: Addison-Wesley.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* Cambridge, England: Cambridge University Press.

Lipman, M. (1976). Philosophy for children. *Metaphilosophy, 7,* 17–39.

Lipman, M., Sharp, A. M., & Oscanyan, F. (1980). *Philosophy in the classroom.* Philadelphia: Temple University Press.

Mansfield, R. S., Busse, T. V., & Krepelka, E. J. (1978). The effectiveness of creativity training. *Review of Educational Research, 4,* 517–536.

Manuel, H. T. (1962). *Test of General Ability: Inter-American series* (Level 4, Forms A & B). San Antonio, TX: Guidance Testing Associates.

McTighe, J., & Lyman, F. T. (1988). Cueing thinking in the classroom: The promise of theory embedded tools. *Educational Leadership, 45*(7), 18–24.

Means, M. L., & Voss, J. F. (1996). Who reasons well? Two studies of informal reasoning among children of different grade, ability and knowledge levels. *Cognition & Instruction, 14*(2), 139–178.

Moreno, J. M., & Hogan, J. D. (1976). The influence of race and social class level on the training of creative thinking and problem-solving abilities. *Journal of Educational Research, 70,* 91–95.

Nickerson, R. S. (1989). On improving thinking through instruction. *Review of Research in Education, 15,* 3–57.

Nickerson, R., Perkins, D. N., & Smith, E. (1985). *The teaching of thinking.* Hillsdale, NJ: Erlbaum.

Olson, D. R., & Astington, J. W. (1993). Thinking about thinking: Learning how to take statements and to hold beliefs. *Educational Psychologist, 28,* 7–23.

Osborne, R., & Freyberg, P. (1985). *Learning in science: The implications of children's science.* Auckland, New Zealand: Heinemann.

Otis, A. S., & Lennon, R. T. (1977). *Otis–Lennon School Ability Test* (Intermediate Level 1, Form R). New York: Harcourt Brace Jovanovich.

Palincsar, A., & Brown, A. (1984). Reciprocal teaching of comprehension fostering and monitoring activities. *Cognition and Instruction, 1*(2), 117–175.

Palincsar, A., Ransom, K., & Derber, S. (1988). Collaborative research and the development of reciprocal teaching. *Educational Leadership, 46,* 37–40.

Perkins, D. N. (1985). Postprimary education has little impact on informal reasoning. *Journal of Educational Psychology, 77,* 562–571.

Perkins, D. N. (1995). *Outsmarting IQ: The emerging science of learnable intelligence.* New York: Free Press.

Perkins, D. N., Farady, M., & Bushey, B. (1991). Everyday reasoning and the roots of intelligence. In J. Voss, D. N. Perkins, & J. Segal (Eds.), *Informal reasoning* (pp. 83–105). Hillsdale, NJ: Erlbaum.

Perkins, D. N., Goodrich, H., Tishman, S., & Mirman-Owen, J. (1994). *Thinking connections: Learning to think & thinking to learn.* Menlo Park, CA: Addison-Wesley.

Perkins, D. N., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *The Merrill-Palmer Quarterly, 39,* 1–21.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1992). Accommodation of a scientific conception: Toward a theory of conceptual change. In M. K. Pearsall (Ed.), *Scope, sequence, and coordination of secondary school science: Relevant research. Vol. II* (pp. 253–270). (Original work published 1982)

Psychological Corporation. (1978). *Metropolitan Achievement Tests* (5th ed.). Cleveland, OH: Author.

Rand, Y., Tannenbaum, A. J., & Feuerstein, R. (1979). Effects of instrumental enrichment on the psychoeducational development of low-functioning adolescents. *Journal of Educational Psychology, 71,* 751–763.

Ross, W. D. (Ed.). (1965). *Aristotelous analytika: Aristotle's prior and posterior analytics.* Oxford, England: Clarendon Press. (Original work published 1877)

Salomon, G. (1993). No distribution without individuals' cognition: A dynamic interactional view. In G. Salomon (Ed.), *Distributed cognitions* (pp. 111–138). New York: Cambridge University Press.

Salomon, G., & Perkins, D. N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist, 24,* 113–142.

Scardamalia, M., & Bereiter, C. (1985). Fostering the development of self-regulation in children's knowledge processing. In S. F. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills, Vol. 2: Research and open questions* (pp. 563–577). Hillsdale, NJ: Erlbaum.

Scarr, S. (1989). Protecting general intelligence: Constructs and consequences for interventions. In R. L. Linn (Ed.), *Intelligence: measurement, theory, and public policy* (pp. 74–118). Chicago: University of Illinois Press.

Schoenfeld, A. H. (1979). Explicit heuristic training as a variable in problem solving performance. *Journal for Research in Mathematics Education, 10,* 173–187.

Schoenfeld, A. H. (1982). Measures of problem-solving performance and of problem-solving instruction. *Journal for Research in Mathematics Education, 13,* 31–49.

Schoenfeld, A. H., & Herrmann, D. J. (1982). Problem perception and knowledge structure in expert and novice mathematical problem solvers. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 484–494.

Segal, J. W., Chipman, S. F., & Glaser, R. (Eds.). (1985). *Thinking and learning skills, volume 1: Relating instruction to research.* Hillsdale, NJ: Erlbaum.

Shipman, V. C. (1983). Evaluation replication of the Philosophy for Children Program—Final report. *Thinking: The Journal of the Philosophy for Children, 5*(1), 45–47.

Stanovich, K. E. (1994). Dysrationalia as an intuition pump. *Educational Researcher, 23*(4), 11–22.

Sternberg, R. J. (1985). *Beyond I.Q.: A triarchic theory of human intelligence.* New York: Cambridge University Press.

Sternberg, R. J., Ferrari, M., Clinkenbeard, P., & Grigorenko, E. L. (1996). Identification, instruction, and assessment of gifted children: A construct validation of a triarchic model. *Gifted Child Quarterly, 40,* 129–137.

Sternberg, R. J., & Wagner, R. K. (Eds.). (1986). *Practical intelligence: Nature and origins of competence in the everyday world.* New York: Cambridge University Press.

Strike, K. A., & Posner, G. J. (1985). A conceptual change view of learning and understanding. In L. H. T. West & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 211–231). New York: Academic Press.

Swartz, R. J., & Parks, S. (1994). *Infusing the teaching of critical and creative thinking into elementary instruction: A lesson design handbook.* Pacific Grove, CA: Critical Thinking Press and Software.

Swartz, R. J., & Perkins, D. N. (1989). *Teaching thinking: Issues and approaches.* Pacific Grove, CA: Midwest Publications.

Thomson, G. H. (1916). A hierarchy without a general factor. *British Journal of Psychology, 8,* 271–281.

Thorndike, E. L. (1923). The influence of first year Latin upon the ability to read English. *School Sociology, 17,* 165–168.

Tishman, S., & Perkins, D. N. (1997). The language of thinking. *Phi Delta Kappan, 78,* 368–374.

Tishman, S., Perkins, D. N., & Jay, E. (1995). *The thinking classroom.* Boston: Allyn & Bacon.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Whimbey, A. (1975). *Intelligence can be taught.* New York: E. P. Dutton.

Whimbey, A., & Lochhead, J. (1982). *Problem solving and comprehension.* Hillsdale, NJ: Erlbaum.

White, B., & Frederiksen, J. (1995). *An overview of the ThinkerTools Inquiry Project* (Causal Models Research Group Report 95-04). Berkeley: University of California, School of Education.

Williams, W., Blythe, T., White, N., Li, J., Sternberg, R., & Gardner, H. (1996). *Practical intelligence for school handbook.* New York: Harper Collins.

Wolfram, S. (1988). *Mathematica: A system for doing mathematics by computer.* Redwood City, CA: Addison-Wesley.